Advances in Engineering Research (AER), volume 72
2016 International Conference on Architectural Engineering and Civil Engineering (AECE-16)

Designing and Analyzing Base Isolation of Frame Structure

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***Abstract*—Nearly thirty years since the base-isolated structure in structural testing and actual earthquake that exhibit excellent shock resistance, it has aroused wide attention from domestic and international academic circles and engineering circles. The base isolation technique has become a new kind of anti-seismic strategy. It not only applies to the new building design, but also for the old house reinforcement and precious historical relics protection opens up a new way. It is the isolation layer which arranged between the base and the upper structure, by reducing the seismic energy to the upper structure, to effectively protect the safety of upper structure and its internal facilities in the strong earthquake. In this paper, researching based on the theoretical research results and combined with the specific engineering examples.**

Keywords-frame structure; base isolation; isolation design; isolation analysis

I. SURVEY

A. General survey of Engineering

Panzhihua City, Sichuan Province, a file office building covers an area of 1026.9m^2, the total construction area is 6498.9m^2, the project is a frame structure building which has 6 floors on the ground (One floor is an underground garage), Ground 1 layers of high is 3.6m, 2 layers of high is 4.2m, and the rest of each layer is 3.6m, the appearance of the building is a sector, the width is 21.5m, the east side is 52.9m, the west side is 42.2m.

B. General Situation of Engineering Geology

1) Stratigraphic lithology:

According to the geological survey and exploration, the main formation of the proposed site is: Quaternary Holocene artificial accumulation (Q^{4ml}) Miscellaneous filling, Quaternary Holocene alluvial (Q^{4dl+pl}) silty clay, Quaternary Pleistocene alluvial (Q^{3al+pl}) gravel silty clay, pebble.

2) Site stability analysis and suitability evaluation:

The proposed site is located in the middle section of the fault zone of the Anling River; the main active faults are the two faults of the West, the east of the Anling River, Li Mingjiu fault and Xigeda fault. According to the drilling exposure and the combination of geological survey, the main component in the field of soil is late Quaternary Pleistocene alluvium (Q^{3al+pl}). Now in a stable state, it did not find the collapse of adverse geological slip. The whole site is not found adverse geological to affect the safety of buildings (structure), the stability of the site is better.

3) Seismic effect evaluation:

The proposed site within the Quaternary overburden layer thickness, the exploration depth is not exposed bedrock, In accordance with the relevant provisions of the code for" seismic design of buildings" (GB5011-2010) , site soil is soft ground soil, belongs to class II construction site, is a general section of the building which can be carried out.

C. Engineering Seismic Design Parameters

1) The fortification intensity of the project:

The seismic fortification intensity of the building site is 7 degrees (The basic seismic acceleration is 0.10g).

2) Site type and seismic grouping:

The building site is a class II, and the design earthquake is grouped into third groups, and the site characteristic period is Tg=0.45s.

3) Peak value of seismic wave acceleration:

Multi earthquake peak acceleration takes 35.0cm/s2. Rare earthquake peak acceleration takes 220.0cm/s2.

4) Shock absorbing target:

According to the research ideas and objectives of this paper, this project is proposed to be reduced to 6 degrees (0.05g). Using base isolation technology reduce seismic response of the upper structure at one time, improving the seismic performance of the structure, while ensuring that the wind load and small earthquakes in the upper part of the building does not shake, improving safety performance and comfort.

II. BASE ISOLATION SCHEME

A. Isolation Bearing Arrangement Scheme

Through analyzing buildings and structures of construction plans for this project, the isolation layer disposed on the top surface of foundation (at -3.400m) and the basement. Install one or more isolation bearing in the bottom of pillars in the basement and the top surface of the base, the upper structure is separated from the lower part of the base, in order to isolate the seismic energy and reducing the role of the upper structure by the earthquake.

B. Arrangement of Isolation Bearing

According to PKPM internal force calculation file of the project, extract the maximum axial force combination of each column under a layer of floor, then follow "Seismic Design of Buildings" (GB50011-2010) Section 12.2.3.

Article 12, it shows that, Class C buildings isolators average stress limits should be less than or equal 15.0Mpa, it can determine the diameter of each isolation bearings [1]. The isolation bearings used in this project are LRB600 type, LNR700, LNR800 and LRB800 type of a total of four models. The base isolation bearing arrangement plan of this project is shown in Figure 1.

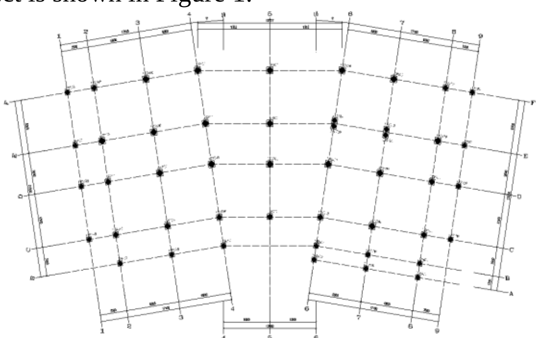

Figure 1. Isolation bearing arrangement plan

III. Correctness Verification of Structural Calculation Models

A. Calculation Model Establishment

This project uses ETABS to calculate the natural vibration characteristics and internal forces of the non-isolated structure. When the structure is calculated and analyzed, Beams and columns are calculated using spatial beam column element, the concrete slab is calculated by using the membrane element, and modeled by the assumption of rigid floor. Using ETABS to establish the three-dimensional model of the structure, shown in Figure 2.

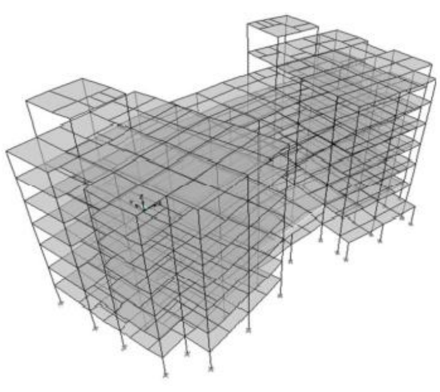

Figure 2. Miyi County Archives built ETABS model map

B. Time History Seismic Wave Selection

Seismic wave selection according to the “code for seismic design of buildings” (GB 50011-2010), the history analysis method, according to the construction site classification and the seismic design group selection of not less than two groups of actual earthquake records and a set of artificial acceleration curve simulated earthquake acceleration history curve of degree [2].

IV. Seismic Response Analysis of Isolated Structures

The time history analysis of the isolated model and the model of the non-isolated model were carried out by using ETABS, and compared, and then the first six order modes of the structure are calculated [3]. The experimental results show that the three sets of real strong earthquake records and a set of artificial simulated acceleration time history curve is more safe and reasonable [4].

A. Natural Vibration Characteristics of Isolated Structures (Table 4.1)

TABLE I. Comparison of the period before and after isolation

Modal order	*structure period before isolation (s)*	*structure period after isolation (s)*
1	1.079957	2.233209
2	1.038969	2.158853
3	0.955095	2.018727
4	0.342056	0.520226
5	0.324859	0.515925
6	0.300968	0.476543

B. The Determination of Level Damping Coefficient β

According to relevant regulations, "code for seismic design of building structures" (GB50011-2010), the level of each floor to this project damping coefficient β [5], as shown in Table 4.2 and Table 4.3.

TABLE II. Comparison of shear force between X direction before and after base isolation

Floor	***Damping coefficient of X direction***			
	EL-Centro	**Artificial wave**	**TAFT**	**average value**
8	0.211	0.174	0.094	0.159
7	0.291	0.327	0.134	0.250
6	0.305	0.409	0.154	0.289
5	0.331	0.434	0.187	0.317
4	0.375	0.442	0.294	0.370
3	0.418	0.466	0.232	0.372
2	0.464	0.506	0.108	0.359
1	0.502	0.554	0.089	0.381

TABLE III. Comparison of shear force between Y direction before and after base isolation

Floor	***Damping coefficient of Y direction***			
	TAFT	**Artificial wave**	**TAFT**	**average value**
8	0.174	0.174	0.094	0.159
7	0.251	0.327	0.134	0.250
6	0.280	0.409	0.154	0.289
5	0.307	0.434	0.187	0.317
4	0.338	0.442	0.294	0.370
3	0.363	0.466	0.232	0.372
2	0.386	0.506	0.108	0.359
1	0.419	0.554	0.089	0.381

From the above results, it shows that the base isolation technology is used in this project, the shear stress is greatly reduced, and the maximum Level damping coefficient β is 0.381. According to the “code for seismic design of buildings” (GB50011-2010).When the range of Level damping coefficient β is located at 0.40 > 0.27 [6], the seismic response of the superstructure can be reduced at one time.

V. CONCLUSION

After the base isolation is adopted in this project, the period of the structure is prolonged by about 2 times, and the earthquake action is greatly reduced. After isolation, the horizontal displacement of the structure is concentrated in the isolation layer, then the base shear and the inter story acceleration are greatly reduced, the structure shows translational. Therefore, the multilayer frame structure system which build in the seismic fortification of 7 degree area (the basic seismic acceleration is 0.10g), class II construction site, design earthquake grouping into third groups, and site characteristic period is Tg=0.45s, can be used by the laminated rubber bearing base isolation system that can obtain better shock absorption effect.

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